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WHEAT CULTIVAR PERFORMANCE UNDER NO-TILL AND TRADITIONAL AGRICULTURE

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ABSTRACT

No-till (NT) is a component of conservation agriculture that can enhance resilience to climate change and reduce costs, soil erosion and fertility decline. Yields under NT can be improved by optimising crop management practices, including better adapted cultivars. To explore possibilities opened by identifying wheat cultivars better adapted to NT agriculture, eight cultivars were tested in parallel yield trials organized in South Romania, during six years, under NT after soybeans or maize and under Traditional agriculture.

The average performance of cultivars under no-till agriculture was not significantly correlated with the performance under the traditional system, with correlation coefficients higher and close to significance between NT system after maize and traditional system (r=0.69) and even negative but non-significant between NT after soybeans and traditional system. Cultivars reacted differently to NT agriculture, the yield differences between NT and traditional system averaged over six years varying from -419 kg ha^{-1} to more than 1000 kg ha^{-1}. Years, Crop Management Systems and Cultivars (in this order of impact), as well as the interactions between Cultivars*Years, and Systems*Years, had significant effects on the variation of the yield differences between agricultural systems. These results underline the importance of yield testing under NT for appropriate recommendation of most suitable cultivars, and suggest that genetic progress in creating cultivars more adapted to conservation agriculture is possible.

Keywords: wheat, cultivars, no-till agricultural system, traditional agriculture, yield.

INTRODUCTION

No-till (NT) agricultural system is an important component of conservation agriculture and is widely recognized as one of several climate-smart agriculture management practices that improve food security and enhance resilience to climate change, reduce costs, soil erosion and fertility decline.

Based on a long-term sustainability field trial, initiated in 2010 at the National Agricultural Research and Development Institute (NARDI) Fundulea, Cociu and Cizmaş (2013) and Cizmaş and Cociu (2015), concluded that conservation agriculture could be considered an important option towards sustainable agriculture for the Eastern Romanian Danube Plain.

A global meta-analysis of no-till relative to conventional tillage yields using 678 studies representing 50 crops and 63 countries showed that no-till reduced yields, on average, by 5.1% across 50 crops and 6005 paired observations, and demonstrated that no-till performed best under rainfed conditions in dry climates, with yields often being equal to or higher than conventional tillage practices (Pittelkow et al., 2015). This study concluded that results obtained under no-till agriculture might be improved by applying most suitable crop management practices.

The performance of wheat genotypes may vary in response to tillage and residue management, and specific genotypes are recommended for no-till (Cox, 1991; Cheţan et al., 2016; Chhokar et al., 2017, 2018). This paper is an attempt to explore possibilities to improve wheat performance under no-till agriculture by using better-adapted cultivars.

MATERIAL AND METHODS

Yield trials with winter wheat cultivars were conducted in parallel during six years

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(2014-2019) at NARDI Fundulea (44º27’45” N latitude and 26º31’35” E longitude, 68 m above sea level) on the multi-disciplinary research Platform for Conservation Agriculture initiated in 2010, and in the wheat breeding field.

Eight wheat cultivars were common to all yield trials, over all 6 years and were included in this analysis. Crop management practices used in the yield trials analysed in this paper are presented in Table 1.

Table 1. Elements of crop management practices used in yield trials performed under no-till and traditional systems

	In the Platform for Conservation Agriculture		In the wheat breeding field
Experimental design	Randomized blocks		Balanced lattice
Harvested plot size	20 m^2		5 m^2
Preceding crop	Soybeans	Maize	Peas
Tillage	No till		Disk
Sowing date	1-10 October		10-20 October
Herbicides	Gliphosate before sowing as needed to maintain the soil clean of weeds 10 g tribenuron-methyl 100 g fluoroxypyr		Gliphosate before sowing 10 g thifensulfuron-methyl 10 g tribenuron-methyl 100 g fluoroxypyr
Fertilizers	Autumn: N 30 kg ha^{-1} + P_2O_5 80 kg ha^{-1} Spring: N 90 kg ha^{-1}		Autumn: P_2O_5 80 kg ha^{-1} Spring: N 138 kg ha^{-1}
Harvest	Wintersteiger combine		

The main difference between the two fields was represented by the tillage system, but beside this there were several minor differences regarding fertilization, date of sowing etc. that were confounded with the main effect of the agricultural system. Based on previous observations (not shown here) we considered that these small differences of crop management probably did not significantly affect the differential performance of cultivars between the two trials.

The weather conditions during the six years of testing are presented in Table 2.

Table 2. Weather conditions during the experiments

Year	October				November				December				January				February			
	Temperature (°C)			Rain (mm)	Temperature (°C)			Rain (mm)	Temperature (°C)			Rain (mm)	Temperature (°C)			Rain (mm)	Temperature (°C)			Rain (mm)
	Average	Max	Min		Average	Max	Min		Average	Max	Min		Average	Max	Min		Average	Max	Min	
2013-2014	11.3	24.6	-1.1	67.0	7.8	23.5	-4.8	20.7	-0.5	11	-8.4	0.2	-0.7	13.5	-16.7	37.1	1.0	17.5	-15	1.7
2014-2015	10.3	26.2	-0.2	56.7	5.0	17.5	-2.2	59.1	0.6	14.5	-14.2	119.4	-1.4	12.2	-18.5	30.8	2.1	14.0	-7.0	40.8
2015-2016	10.7	24.2	-2.9	47.0	7.9	24.2	-2.9	94.3	3.0	13.5	-7.5	2.8	-4.3	10.0	-22.6	53.0	6.2	22.8	-4.1	10.3
2016-2017	10.7	25.9	1.1	74.4	5.7	18.5	-3.2	48.8	-0.3	12.5	-8.8	0.0	-5.5	5.7	-23.8	35.4	0.0	17.3	-13.5	50.5
2017-2018	11.2	26.5	1.8	111.6	7.0	19.7	-1.1	49.2	3.6	15.3	-4.5	27.8	0.8	13.7	-10.8	36.0	1.6	16.4	-9.8	58.6
2018-2019	13.4	27.4	2.8	10.8	5.2	19.7	-5.3	23	-0.1	9.3	-10.7	43.0	-1.2	4.9	-12.6	53.8	3.8	16.2	-5.7	21.4

Year	March				April				May				June				July			
	Temperature (°C)			Rain (mm)	Temperature (°C)			Rain (mm)	Temperature (°C)			Rain (mm)	Temperature (°C)			Rain (mm)	Temperature			Rain (mm)
	Average	Max	Min		Average	Max	Min		Average	Max	Min		Average	Max	Min		Average	Max	Min	
2013-2014	8.5	23.0	-0.1	38.1	10.9	24.2	3.2	82.8	16.0	30.0	3.8	100.6	19.3	31.0	11.6	136.2	22.3	33.5	13.7	52.0
2014-2015	5.9	20.2	-4.8	78.8	11.0	26.2	-1.5	47.0	18.3	28.8	8.5	30.0	21.1	34.5	11.0	51.9	25.1	38.8	11.8	36.8
2015-2016	7.3	23.8	-2.0	54.9	13.9	29.8	0.0	73.7	15.9	30.4	4.5	81.2	23.0	35.8	10.8	43.7	24.1	35.7	13.7	31.3
2016-2017	10.9	21.9	-0.5	47.6	10.6	28.0	0.3	73.4	16.8	29.3	4.1	65.8	22.2	36.8	12.6	96.4	23.4	39.2	12.7	113.6
2017-2018	12.4	23.3	-18.4	40.6	15.8	28.9	2.6	2.4	19.5	30.7	8.1	34.0	22.6	33.1	12.3	120.6	23.6	30.8	12.7	85.0
2018-2019	9.3	25.8	-3.1	21.6	11.2	26.8	-0.8	51.4	17.2	28.9	7.8	124.2	23.6	33.6	15.2	74.6	23.0	36.1	12.3	87.4

The years when the analysed trials were performed differed in most weather parameters. For example, rainfall during the months of March-July varied from 244.4 in 2015 to 409.7 mm in 2014, and rainfall in May varied from 34.0 in 2018 to 124.2 mm in 2019. Average temperature in October, which might have influenced emergence, varied from 10.3°C in 2015 to 13.4°C in 2019.

RESULTS AND DISCUSSION

The average performance of cultivars under NT agriculture was not significantly correlated with the performance under the traditional system. Correlation coefficients between average yields were higher and close to significance between no-till system after maize and traditional system (r=0.69) and even negative but non-significant between no-till system after soybeans and the traditional system (Table 3).

Table 3. Correlation coefficients between cultivar performances under No-till and Traditional management systems

Year	Crop management system	Traditional with N fertilization
2014	No-till after Soybeans	-0.23
	No-till after Maize	0.59
2015	No-till after Soybeans	-0.03
	No-till after Maize	0.23
2016	No-till after Soybeans	-0.62
	No-till after Maize	-0.45
2017	No-till after Soybeans	0.18
	No-till after Maize	**0.73***
2018	No-till after Soybeans	0.52
	No-till after Maize	0.68
2019	No-till after Soybeans	0.21
	No-till after Maize	0.05
Average 2014-2019	No-till after Soybeans	-0.08
	No-till after Maize	0.69

In only one year and one of the preceding crops the cultivar performance was positively correlated significantly between the two agricultural systems. In the rest, correlations were not significant, but very variable in various years, ranging from -0.62 to +0.68.

It is difficult to identify one weather characteristic that might explain the variation of correlations, but one could speculate that it might be related to conditions during emergence and early growth or water availability that are generally different under no-till and traditional cropping systems.

Cultivar ranking according to yields averaged over six years was different under the tested crop management systems (Table 4).

Table 4. Grain yields of several wheat cultivars averaged over six years, under various crop management systems

Cultivar \ Agricultural system	No-till after soybean	No-till after maize	Average No-till	Traditional
Miranda	5619	**5673**	**5646**	6242
Glosa	5533	5644	5589	6295
Otilia	**5640**	5511	5576	**6437**
Izvor	5551	5577	5564	5984
Litera	5469	5384	5427	6134
Pajura	5461	5379	5420	6408
Pitar	5223	5156	5190	6377
Boema 1	5489	4242	4865	5651

The top yields for each crop management systems are written in **bold**.

With the exception of the cultivar Otilia, which ranked first both under traditional agriculture and under no-till after soybean and fourth after maize, the highest yielding cultivars under no-till were different than under traditional crop management.

Cultivars reacted differently to no till agriculture, the average yield difference between no-till and traditional system varying from -419 kg ha^{-1} in cultivar Izvor to more than 1000 kg ha^{-1} in cultivar Pitar (Table 5).

Table 5. Six years average yield differences between No-till and Traditional management systems in several wheat cultivars

Cultivar \ Agricultural system	Yield difference between No-till and Traditional system		
	No-till after soybean	No-till after maize	Average No-till
Izvor	-432	**-406**	**-419**
Miranda	-623	-569	-596
Glosa	-762	-651	-706
Litera	-665	-751	-708
Boema 1	**-163**	-1410	-787
Otilia	-797	-926	-861
Pajura	-947	-1029	-988
Pitar	-1154	-1220	-1187
Average	-693	-870	-782

The smallest yield differences for each comparison between crop management systems are written in **bold**.

Further research is necessary to identify traits that can reduce the negative influence of no-till on cultivar performance and to use this knowledge in breeding for better adaptation to this management system.

ANOVA for the yield differences between crop managements showed significant effects of Years, Crop Management Systems and Cultivars (in this order of impact), as well as of the interactions between Cultivars*Years, and Systems*Year, when tested against the C*S*Y interaction (Table 6). The total interaction between Cultivars and mangement Systems was not significant, because many of the cultivars reacted the same way to the specific of management systems. However, as shown in Table 5, a few of the cultivars showed a different response to management systems.

Table 6. ANOVA for the yield differences between crop management systems

Source of variation	SS	df	MS	F value and probability (against Interaction C*S*Y)	F value and probability (against Interactions with Years)
Cultivars	8341461	7	1191637	3.64**	0.44 n.s.
Systems	13044927	3	4348309	13.28**	2.00 n.s.
Years	514765363	5	1.03E+08	314.40***	
Interaction C*S	9795747	21	466464	1.42 n.s.	
Interaction C*Y	95598800	35	2731394	8.34**	
Interaction S*Y	32657355	15	2177157	6.65**	
Interaction C*S*Y	34383538	105	327462		
Total	708587191	191			

n.s., **, *** - non significant, significant at p=0.05, 0.01 and 0.001, respectively.

Because of the high value of their interactions with the years, the effect of Cultivars and Systems were not significant when tested against the interactions with Years.

These results suggest that response to NT agriculture might be due to many traits of different importance in different years. Further research is necessary to better understand the complexity of this response.

CONCLUSIONS

Wheat cultivar recommendations for No-till agriculture should be based on testing under the specific conditions of this agriculture system, because some cultivars react differently to these conditions.

The differenced observed between cultivars in response to NT agricultural system could open perspectives of genetic progress in creating cultivars more adapted to conservation agriculture.

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